engineering laboratory

Modeling Methodology for Smart Manufacturing

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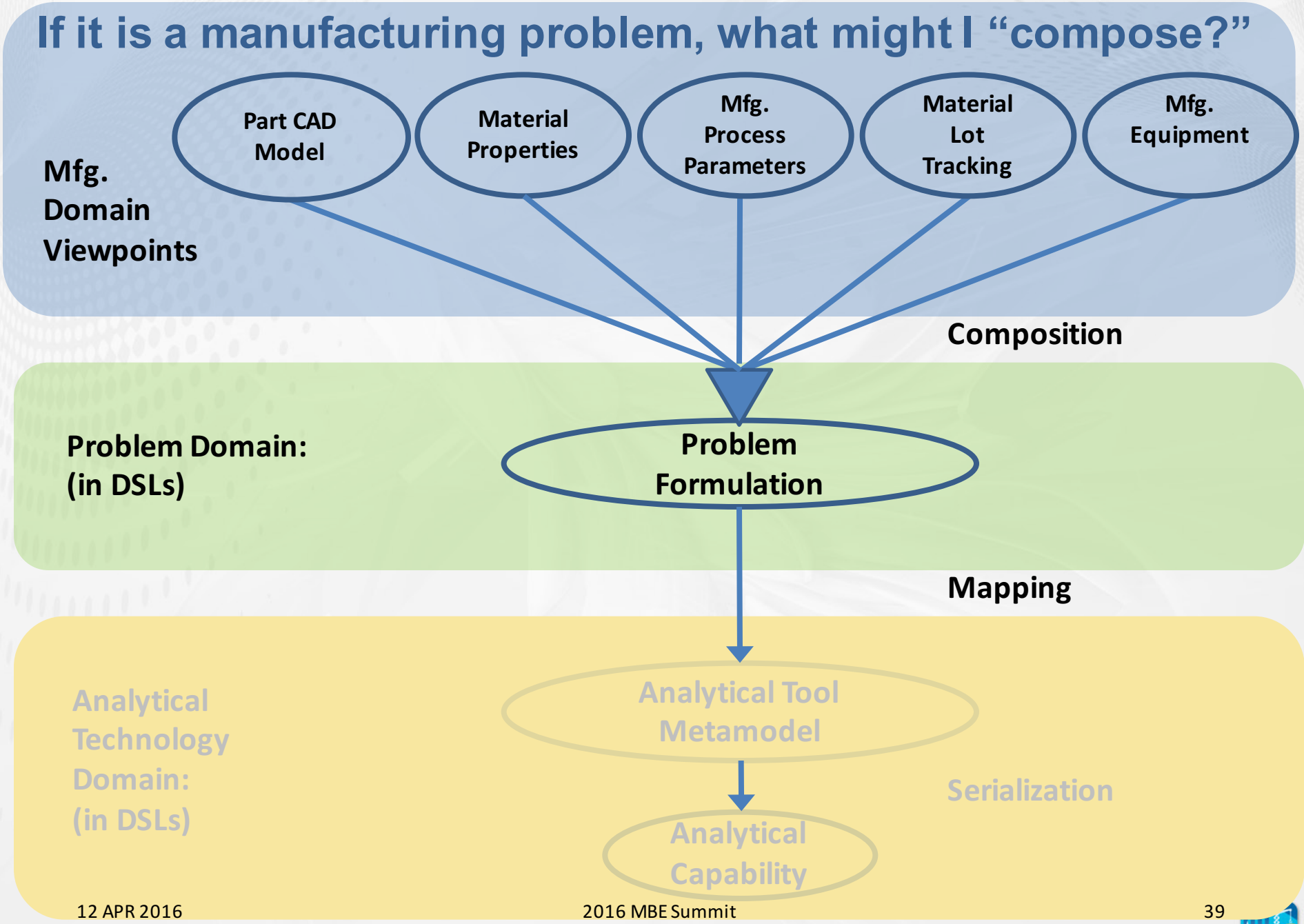
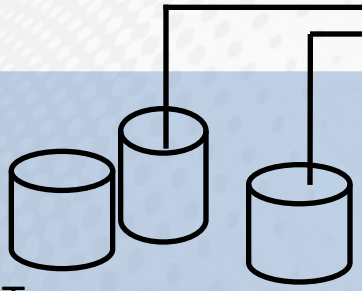
Where does the fault originate?

- Misjudged operating environment?
- Maintenance?
- Materials?
- Manufacturing process?

If it is a manufacturing problem, what might I "compose?"



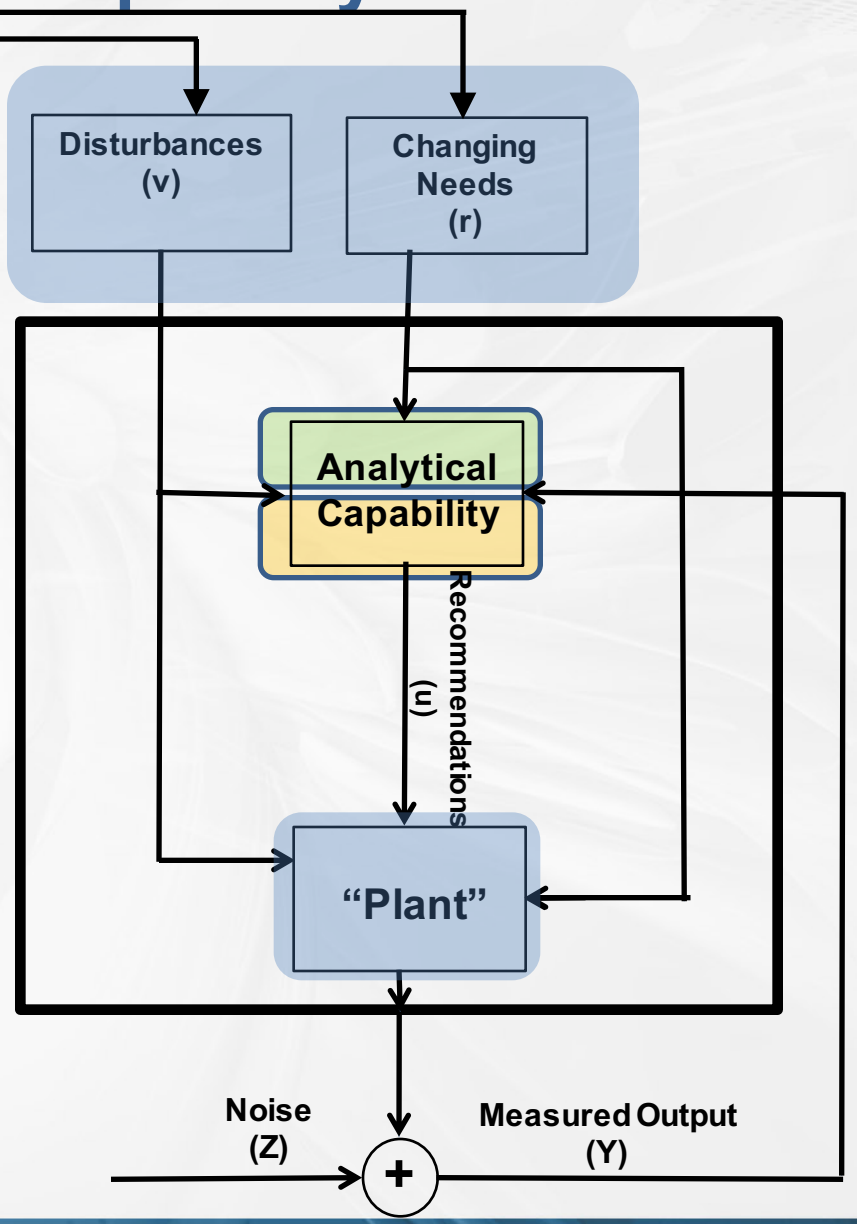
Example: Replace the "consultant paradigm" with embedded analytical capability



System IT resources,
control system,
knowledge of system environment

Impediments to Operational Performance

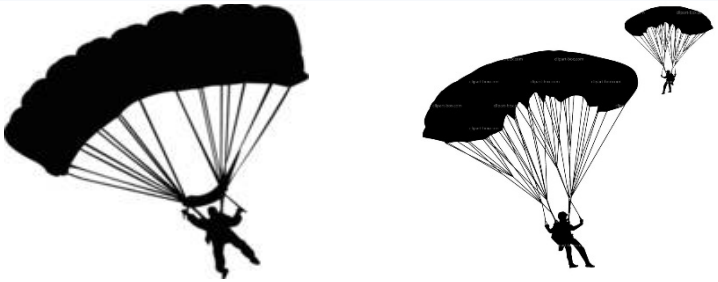
- Poor Manufacturability
- Unavailability of production resources
- Variation in component quality
- Variation in demand for products
- Many product configurations
- Engineering change of product
- Unavailability of components
- Obsolescence of components
- Obsolescence of finished goods
- Integrating new component technology
- Integrating new production processes
- Integrating new materials
- Integrating new equipment
- Equipment maintenance
- Equipment anomalies
- Equipment incompatibility
- Change in cost of logistics
- Tooling change
- Labor shortage
- Strikes
- Cyber-attacks



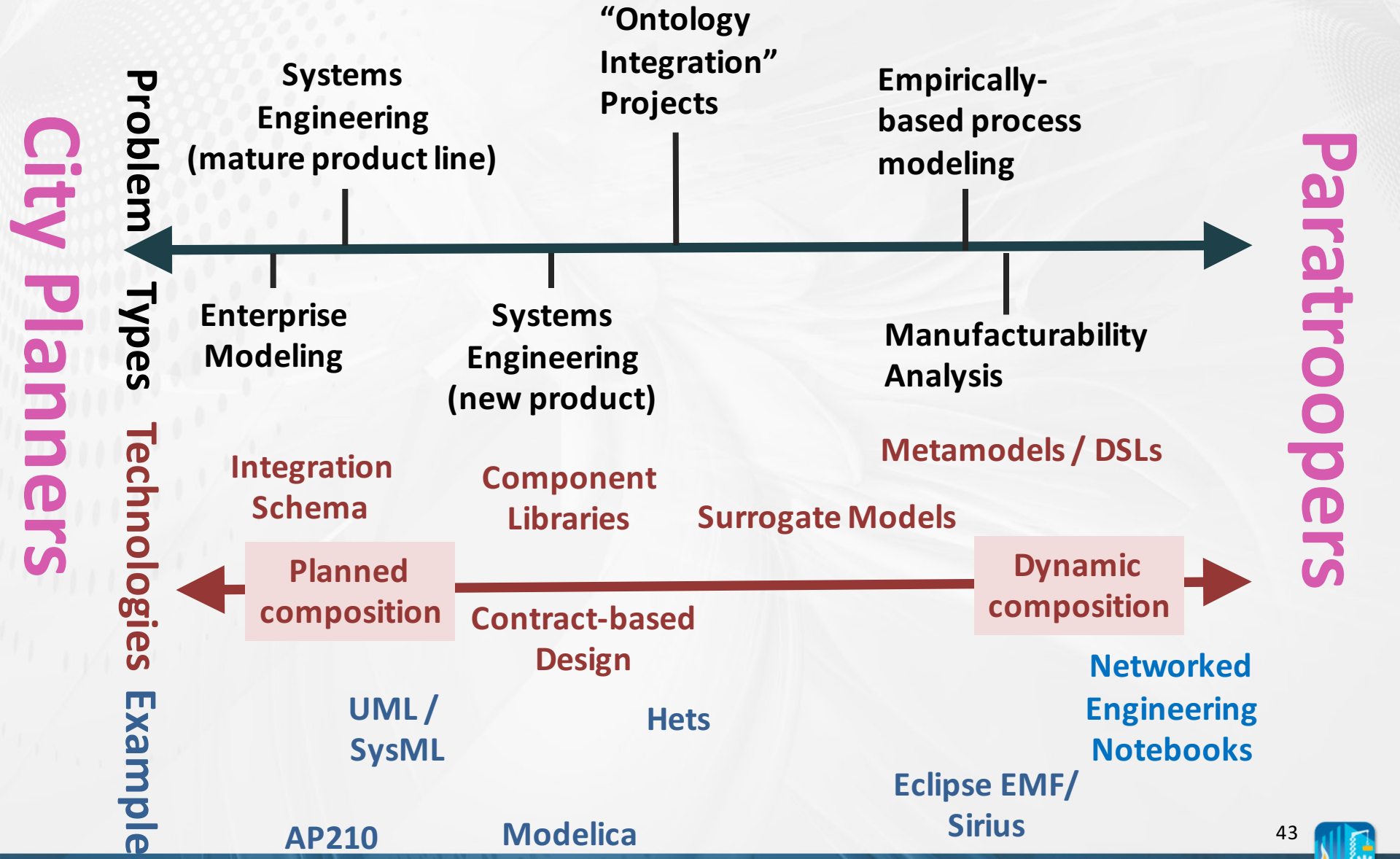
Model composition

- the act of combining information from multiple **disparate sources** so as to enable **inference** that is not possible from the sources individually.
  - Related terms: data fusion, model integration, semantic interoperability, more comprehensive representation
  - **disparate sources** = sources differing in viewpoint, structure, and upper ontology
  - **inference** = a deductive, inductive, or abductive process. (quantitative or qualitative)

The diverse usage patterns and characteristics of model composition problems

Usage Pattern → / Characteristic ↓	"City planners" (planned composition)	"Paratroopers" (dynamic composition)
		
Control:	Extensive, continuous	very little, to start
Objectives:	many, interrelated	few
Knowledge:	circumspect, buy as needed	vague at first, non-monotonic, dynamic, learning
Time:	Projects come and go, the job will always be there	complete on time, or die trying
Money:	on-going	allocated once
Relation to system:	Always "above the system"	become part of system

Spectrum of composition usage patterns



Technical Strategy = Composition Pattern + Method of Verification

- Composition Pattern
  - Service composition
  - Viewpoint ontologies + merging
  - Lumped parameters + ports
  - Object-oriented
  - Contract-based design
  - Hierarchical controller + plant
- Methods of Verification
  - Solvers / Reasoners (Axiomatic, SAT, SMT)
  - Formal by design (e.g. rewriting)
  - Traditional SE system validation

Networked Engineering Notebooks

jupyter

AMdoe - Google Chrome

Home | AMdoe | Peter

localhost:8888/notebooks/AMdoe.ipynb

Apps | Bookmarks | Refs | Projects | Lisp | Modeling | Notes | NIST | News | Misc | Specs | Python | Other bookmarks

jupyter AMdoe Last Checkpoint: 03/24/2016 (autosaved)

File Edit View Insert Cell Kernel Help Python 3

Markdown | Cell Toolbar: None

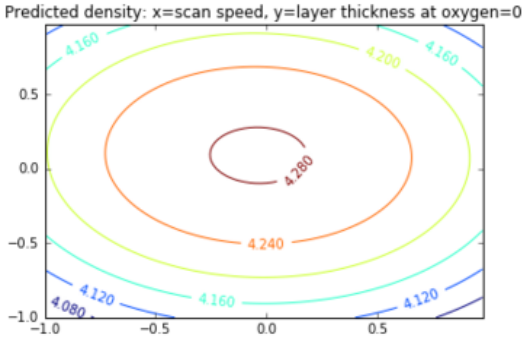
Plot results

POD: In the following, make sure you have the dimensions correct. (Try different deltas. Compare with contour plot example.)

In [23]:
```
delta = 0.025
x_sspeed = np.arange(-1.0, 1.0, delta)
y_lthick = np.arange(-1.0, 1.0, delta)
z_density = np.array([[density_predict(x,y,0) for x in x_sspeed] for y in y_lthick]) # oxygen = 0
x_grid, y_grid = np.meshgrid(x_sspeed, y_lthick)
```

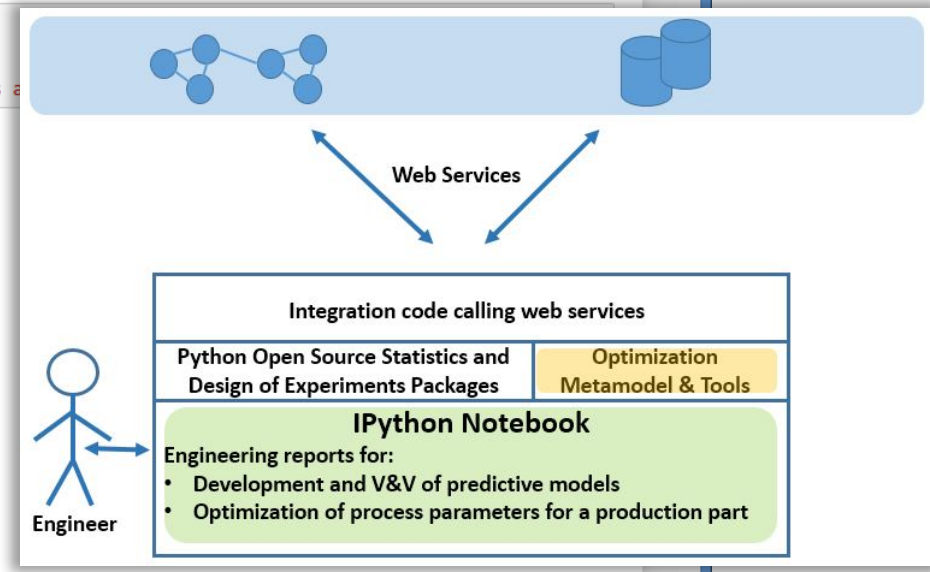
In [24]:
```
plt.figure()
CS = plt.contour(x_grid, y_grid, z_density)
plt.clabel(CS, inline=1, fontsize=10)
plt.title('Predicted density: x=scan speed, y=layer thickness a
```

Out[24]: <matplotlib.text.Text at 0x7fbb4e3d95f8>



Save the completed equation

In [25]:
```
ereps.assert_predictive('Eqn1',density_fit)
```



Summary

- Various relevant notions of composition
- Various technologies fit for purpose
- Notebook technology very promising for "embedded analytical capability."
- NIST is both helping to use notebooks and developing the science of composition.
- NIST is contributing to work to enable verification, with potential for standardization.